Academy of Management Professional Development Workshop 2009
Sheraton Chicago, Huron Room, August 7, 2009

Applied Agent-based Modeling in Management Research

Chairs

Bill McKelvey
Anderson School of Management
University of California, Los Angeles
mckelvey@anderson.ucla.edu

Mike Prietula
Goizueta Business School
Emory University
prietula@bus.emory.edu

+ Presenters

Phil Anderson
INSEAD
Singapore
philip.anderson@insead.edu

Richard Burton
Fuqua School of Business
Duke University
rich.burton@duke.edu

Kathleen Carley
School of Computer Science
Carnegie Mellon University
kathleen.carley@cs.cmu.edu

Zhiang "John" Lin
School of Management
University of Texas at Dallas
zlin@utdallas.edu

Jonathan Ozik
Decision & Information Sciences
Argonne National Laboratory
jozik@anl.gov

Bill Rand
Robert H. Smith School of Business
University of Maryland
wrand@umd.edu

Eric Tatara
Decision & Information Sciences
Argonne National Laboratory
tatara@anl.gov

Primary Sponsor

We thank the enthusiastic support of our primary sponsor, Research Methods
Mark Griffin, University of Sheffield, m.griffin@sheffield.ac.uk

Summary

Computational modeling has a rich history in the physical and computational sciences as a significant type of research method. An emerging approach from that history is a general tactic called agent-based modeling. It is apparent that there are substantial misunderstandings regarding agent-based modeling. It is also apparent that there is a substantial demand for practical information and guidance on how this method (or more accurately, these types of methods) can be applied to management research. As little formal education currently exists in Ph.D. programs in management schools, we believe that an all-academy applied-PDW from the *Research Methods* division that is presented by leading scholars actively engaged in these methods would greatly benefit academy members.

PDW on Applied Agent-based Modeling in Management Research

Schedule

8.00 – 8.30am	**Coffee, Registration, Materials**
8.30 – 8.45am	**Introduction: Why Build a Model?** • Presenter: Mike Prietula (Emory)
8.45 – 9.30am	**How to Build an Agent-Based Model I: CA and GA** • Presenter: Bill McKelvey (UCLA) • Use of Cellular Automata & Genetic Algorithms
9.30 – 10.15am	**How to Build an Agent-Based Model II: NetLogo** • Presenter: Bill Rand (Maryland) • Use of NetLogo integrated ABM development environment
10.15 – 10.30am	**Break**
10.30 – 11.15am	**How to Build an Agent-Based Model III: Repast Simphony** • Presenter: Eric Tatara & Jonathan Ozik (Argonne) • Use of Repast Simphony integrated ABM development environment
11.15 – 12.00pm	**How to Validate an Agent-based Model** • Presenter: Kathleen Carley (CMU)
12.00pm – 12.45pm	**Publishing Your Research (Editors' Forum)** • Presenters: Phil Anderson (INSEAD: *Administrative Science Quarterly)* Richard Burton (Duke: *Organization Science*) Zhiang "John" Lin (UT Dallas: *Computational & Mathematical Organization Theory*) • Short presentations first and responses to questions from participants
12.45pm – 1.00pm	**Wrap-Up**

Section Summaries

Why Build an Agent-Based Model?

Michael Prietula: I will offer a brief introduction to ABM and will discuss the general roles that these types of models can play in organization science research. I will provide a brief overview of the components of the PDW.

How to Build an Agent-Based Model, Part I: CA and GA

Bill McKelvey: I will discuss the problem of how to best fit an ABM to a research problem. I begin by outlining the basic elements of cellular automata (CA) and genetic algorithm (GA) models—two main model platforms. Both types have pluses and minuses for organizational research and testing of hypotheses or experimenting. For CAs I will feature Kauffman's NK model, which now has some 30+ applications to management and strategy. For GAs I will use Macy and Skvoretz's paper[1] to connect social evolution to ABMs.

How to Build an Agent-Based Model, Part II: NetLogo and Repast Simphony

William Rand: I will discuss how to use NetLogo agent-based modeling integrated development environment to create a model. I will illustrate the major components and abilities of NetLogo while creating an agent-based version of the classic Bass Diffusion of Innovation Model, and I will explain where to go for additional help with developing NetLogo models. During this process I will discuss how to verify the model using NetLogo. After the model has been constructed, I will show how to use NetLogo's experimental tools to analyze the model and how to collect results from the model for use in analysis and validation, and provide examples of more complex models that have been built with NetLogo.

Eric Tatara & Jonathan Ozik: We will present a high level overview of the structure and usage of the free and open source Repast Simphony agent-based modeling toolkit using demonstration examples. The brief examples will indicate how model developers can draw visual flowcharts to generate models; execute the models within Repast's point-and-click runtime environment; and then analyze the results using both Repast's runtime environment and free and open source external plugins. Due to limited time, this overview will not show the details of model construction or use but will provide references to step-by-step online tutorials which can be studied separately.

How to Validate an Agent-based Model

Kathleen Carley: I will discuss the types of validation available for ABM's; from face validation to empirical forecasting. The science of validation, well developed in engineering, is based on a series of assumptions that do not hold for most ABM of human socio-cultural systems. These assumptions are discussed as is the need for a new science of validation. Discussions of validation will be illustrated from multiple examples of validation activities.

[1] Macy, M. W., & J. Skvoretz (1998). "The Evolution of Trust and Cooperation between Strangers: A Computational Model." *American Sociological Review,* 63: 638-660.

Publishing Your Research (Editors' Forum)

Philip Anderson: I will emphasize that the main reason why agent based models have difficulties at journals such as *Administrative Science Quarterly* is that changing a small number of assumptions can change the outcome of the model dramatically. Consequently, I recommend a different approach: building several different models that each fit a theoretical perspective on an empirical problem, and showing that only one model produces results consistent with empirical findings. The power of agent-based modeling in this approach is its ability to see which micro-level assumptions fitted to empirical data about a network can produce empirically observed patterns at the collective level. ABM therefore allows us to link actors' understandings and behavior to unexpected configurations that emerge from their interaction, unexpected usually because interactions produce nonlinear outcomes.

Richard Burton: I will discuss some criteria for a successful paper in *Organization Science*: Focus on the organizational issue, question, dilemma, or problem – not the model per se. The general Organization Science reader should be able to follow the story line and understand your question and your contribution to Organization Science -- what did we learn? The model should be explained in sufficient detail that a modeler could follow the model and what you did - in the spirit of transparency and replication. The model and the problem should be clearly linked; that is, the correspondence of the model and the question should be clear. The experimental design should be clear, that is, the manipulation and analysis of the outcomes. The experimental design should be clearly linked to the research question. Parsimony is a virtue. Simple models which address significant issues are preferred. Reality is not a virtue in and of itself.

Zhiang "John" Lin: My objective is to represent *Computational & Mathematical Organization Theory* (CMOT) and describe its goals and manuscript review process at the workshop. In short, I hope to convey to the participants that CMOT is an important publication channel for research that cuts across a wide variety of domains. Papers presenting, validating, or applying models and/or computational techniques, new algorithms, dynamic metrics for networks and complex systems and papers comparing, contrasting and docking computational models are strongly encouraged. I will specifically encourage work that allows the demonstration of usefulness of computational modeling in extending existing theories and creating new theories. For example, it will be interesting to show how computer simulation may allow us to understand the true dynamics of strategic networks, traditionally being explored with static approaches and latent network assumptions based on dyadic events. Like other quality journals, the key to a publishable paper at CMOT is the strong link among three components: a well-defined and important research question, a relevant literature review, and a clear and appropriate research design.

Presenter Biographies

Philip Anderson. Dr. Anderson is the INSEAD Alumni Fund Professor of Entrepreneurship a INSEAD, in Singapore. He is also director of the Rudolf and Valeria Maag International Centre for Entrepreneurship and is academic director of INSEAD's Abu Dhabi Centre. His undergraduate degree in Agricultural Economics is from the University of California at Davis, and he received his Ph.D. in Management of Organizations from Columbia University. A former Army officer, Professor Anderson has also worked as an independent computer consultant, and an MIS manager and Assistant to the President of a large nonprofit organization and an entrepreneurial start-up organization. He has served on the faculties of the Johnson Graduate School of Management at Cornell and the Amos Tuck School of Business at Dartmouth. His research interests include the formation of entrepreneurial businesses, managing growth, processes of technological evolution, strategy implementation, and complexity theory. Professor Anderson is an associate editor of *Administrative Science Quarterly*, and is also the co-editor of a special issue of *Organization Science* on applications of complexity theory to organizational research. He has been the chair of the Technology and Innovation Management division of the Academy of Management.

Richard Burton. Dr. Burton is Professor of Organization and Strategy at The Fuqua School of Business, Duke University. He is also Professor of Management at the EIASM (European Institute for Advanced Studies in Management) in Brussels, and Honorary Professor at the University of Southern Denmark and the University of Aarhus. His research focuses on organizational design and particularly its relationship to strategy for the firm. With Professor Borge Obel, he has authored numerous articles, and books. Their *Strategic Organizational Diagnosis and Design: The Dynamics of Fit* is in its third edition. With the associated software, OrgCon, the book provides an integrated theoretical and practical approach to organizational design for strategy implementation. His most recent book is *Organizational Design: A Step-by-Step Approach,* 2006, with Professors DeSanctis and Obel. He has DBA from the University of Illinois, as well as BS and MBA. He is active on a number of editorial boards, and has been Department Editor for Strategy, Organizational design and Performance for *Management Science*. Currently, he is Senior Editor for *Organization Science*. He has published some sixty articles on strategy, organization and management science, and seven books.

Kathleen Carley. Dr. Carley is a Professor at Carnegie Mellon University in the School of Computer Science. She has an interdisciplinary background with a Ph.D. from Harvard in Mathematical Sociology and undergraduate degrees from MIT in Economics and Political Science. Dr. Carley is the director of the center for Computational Analysis of Social and Organizational Systems (CASOS) which has over 25 members, both students and research staff. Her research combines cognitive science, social networks and computer science to address complex social and organizational problems. She is a pioneer in the areas of dynamic network analysis and computational social and organization theory. She and the CASOS center have developed infrastructure tools for analyzing large scale dynamic networks and various multi-agent simulation systems. The infrastructure tools include: ORA, a statistical toolkit for analyzing and visualizing multi-dimensional geo-temporal networks; AutoMap, a text-mining system for extracting semantic networks from texts and then cross-classifying them using an organizational ontology into the underlying social, knowledge, resource and task networks; and Construct, a multi-agent model for network evolution. Additional simulation models meld multi-agent technology with network dynamics and empirical data and include BioWar a city-scale dynamic-network agent-based model for understanding the spread of disease and illness due to natural epidemics, chemical spills, and eaponized biological attacksShe is the founding co-editor with Al. Wallace of the journal Computational

rganization Theory and has co-edited several books in the computational organizations and dynamic network area and over 140 papers.

Zhiang "John" Lin. Dr. Lin has a Ph.D. from Carnegie Mellon University and is an associate professor of organization theory and strategic management at the University of Texas at Dallas. His research focuses on computational organization theory, social networks, and strategic decision making. His work has appeared in *Organization Science*, *Management Science*, *Academy of Management Review*, *Journal of International Business Studies, Strategic Management Journal, Journal of Management, Journal of Mathematical Sociology*, and *Computational and Mathematical Organization Theory*. He is currently Co-chief Editor for *Computational and Mathematical Organization Theory*.

Bill McKelvey. Dr. McKelvey is professor of Strategic Organizing & Complexity Science at the UCLA Anderson School of Management. Current writing focuses on philosophy of science, organization science, complexity science, agent-based computational modeling, & complexity leadership. His book, *Organizational Systematics* (1982) remains the definitive treatment of organizational taxonomy and evolutionary theory. He chaired the building committee that produced the $110,000,000 Anderson Complex at UCLA—opened in 1994; directed over 170 field study teams on 6-month projects concerned with strategic and organizational improvements to client firms; and initiated the founding of UCLA's Center for Human Complex Systems & Computational Social Science. He has over 70 papers relating complexity science to management.

Jonathan Ozik. Dr. Ozik is a computational social scientist and research fellow at Argonne National Laboratory and the University of Chicago. His interests are in the broad and emerging field of social computation. Dr. Ozik is engaged in research on both applied and fundamental agent-based social modeling. He is also contributing to the improvement of the technical capabilities available to social modelers via agent-based modeling toolkit development. Dr. Ozik received his Ph.D. in Physics from the Chaos and Nonlinear Dynamics Group at the University of Maryland in 2005.

Michael Prietula. Dr. Prietula is Co-Director of Emory's Social and Behavioral Science Research Center, Professor at the Goizueta Business School, and Faculty member of the Center for Neuropolicy at Emory. He received his doctorate in Information Systems from the University of Minnesota, and was a faculty member at Dartmouth, Johns Hopkins and Carnegie Mellon. His research involves multi-level theories of social phenomena and simulations of social dynamics. He is currently funded by the Office of Naval Research, the Centers for Disease Control and Prevention, and the National Science Foundation.

Eric Tatara. Dr. Tatara is a software engineer in the Center for Complex Adaptive Agent Systems Simulation within the Decision and Information Sciences Division of Argonne National Laboratory. He received his Ph.D. in chemical engineering from Illinois Institute of Technology in 2005 where he continues to serve as an adjunct professor teaching graduate level courses in statistical quality control methods. Dr. Tatara has published over 50 journal articles, conference papers, and book chapters in his primary research fields which include industrial process modeling, supervision and control, quality control, agent-based simulation, analysis and simulation of nonlinear dynamical systems, military operations research, and biomedical engineering applications.

William Rand. Dr. Rand is an Assistant Professor of Marketing at the Robert H. Smith School of Business at the University of Maryland. He received his doctorate in Computer Science from the University of Michigan in 2005 where he worked on the application of evolutionary computation techniques to dynamic environments. As a postdoctoral research fellow at Northwestern University in the Northwestern Institute on Complex Systems (NICO), he continued to develop his interest in agent-based modeling and evolutionary computation, and began combining these techniques with social network analysis. Over the course of his research experience, he has used computer models to help understand

a large variety of complex systems, such as the evolution of cooperation, suburban sprawl, traffic patterns, financial systems, land-use and land-change in urban systems, and many other phenomena. Dr. Rand is currently co-authoring a textbook on agent-based modeling.